Eur. J. Soil Biol., 1993, **29** (1), 29-34

Effects of worm density on growth and cocoon production of the African Nightcrawler *Eudrilus eugeniae* (Oligochaeta)

A. J. Reinecke and S. A. Viljoen

Department of Zoology, University of Stellenbosch, Stellenbosch 7600, South Africa.

Received June 27, 1992; accepted September 10, 1992.

Abstract

Worms of the species *Eudrilus eugeniae* were kept at 25,°C in cattle manure at a moisture content of 80%. The influence of worm density on growth and cocoon production was studied. The results showed that worms tend to be smaller and produce fewer cocoons at higher densities in spite of the fact that ample food is provided. Vermiculturists should prevent crowded conditions in worm beds by regular harvesting in order to maintain maximum growth and reproduction.

Keywords: Earthworms, *Eudrilus eugeniae*, density, vermiculture, cocoons, growth.

Effets de la densité des vers sur la croissance et la production de cocons chez le ver de terre africain Eudrilus engeniae *(Oligochaeta).*

Résumé

Des vers de l'espèce *Eudrilus eugeniae* ont été mis en élevage dans du fumier de bovins à un degré d'humidité de 80 %. L'influence de la densité de vers sur la croissance et la production de cocons a été étudiée. Les résultats montrent que les vers deviennent plus petits et que la production de cocons diminue lorsque la densité est élevée, malgré la présence d'une nourriture abondante. La vermiculture doit donc éviter des conditions de densité trop élevée par une récolte regulière de vers, afin de maintenir une croissance et une reproduction maximale.

Mots-clés : ver de terre, *Eudrilius engeniae*, densité, vermiculture, cocons, croissance.

INTRODUCTION

Ever since the potential of earthworms as waste processors and as a source of protein in animal feeds has been established (Graff, 1974; Neuhauser, Loehr and Malecki, 1988; Edwards, 1988; Edwards and Niederer, 1988; Venter and Reinecke, 1988; Reinecke *et al.*, 1991) the search for the most suitable species was on. The feasibility of using vermiculture as a biotechnology depends, among other factors, on the use of the correct species for the specific circumstances. *Eudrilus eugeniae* has been shown to have a high growth rate and a fecundity surpassing that of the well-known compost worm, *Eisenia fetida* (Rodriguez *et al.*, 1986; Viljoen and Reinecke, 1989 *a*; 1990). The applicability of this species for vermiculture under certain environmental conditions has therefore been established.

The success of vermiculture also depends on the ability to maintain high numbers of worms in the culture beds to ensure maximum production of worm biomass or maximum decomposition of organic material. This can be attained in artificial culture beds where the worms are fed regularly. Population densities however tend to stabilize and fluctuate around levels, often below the carrying capacity of the substrate (Reinecke and Viljoen, 1990). These authors have shown for *Eisenia fetida* that worm beds can become overcrowded with a concomitant decline in the reproduction rate.

The present study was undertaken to determine the influence of worm density on the growth

Eur. J. Soil Biol., 93/01 29 06/$ 2.60/© Gauthier-Villars

and reproduction of the lesser known African Nightcrawler, *Eudrilus eugeniae*, since this species shows much promise as a candidate for vermiculture.

MATERIALS AND METHODS

Worms were reared in the laboratory as described by Viljoen and Reinecke (1989 *a*; 1990). In the first series of experiments fifteen (500 ml) flasks (Viljoen and Reinecke, 1989 *b*) were used, each containing 720 g of wetted manure. The cattle manure medium was urine and straw free. The cattle medium was dried, ground and sieved to attain a particle size of 500-1 000 μm and wetted to 80% moisture, Viljoen and Reinecke (1989 *a*) found this moisture level to the favourable for *Eudrilus eugeniae*. The flasks, each with a different number of worms, were placed in an environmental control chamber at a constant temperature of 25 °C and a relative humidity of 80%. Moisture availability was interpreted as discussed by Viljoen and Reinecke (1989 *b*). The substrate was allowed to stabilize for 24 hours. The surface of the substrate in each flask was covered by placing a plastic sheet loosely on top to prevent the upper layers from drying out and to keep the worms in the dark.

The different flasks received 4, 8, 12, 16 and 20 worms each. Five replicates were set up at each density. Only worms with fully developed clitellums and not yet producing cocoons were selected from the stock that were reared individually in flasks since their hatching as described by Reinecke et Viljoen (1990). The flasks were inspected every seven days and searched for cocoons. The biomass of the worms was also determined at this stage and the moisture content of the medium was determined with an infrared moisture detector. The observations were continued over a period of 63 days.

In a second series of experiments conducted under similar conditions with the same medium, containers of different diameters were used. The containers therefore contained different volumes of the substrate but each received six specimens of *Eudrilus eugeniae*. The worms were of the same age. They were placed in each of five perspex cylinders with a height of 8 cm and diameters of 6.9, 10.5, 15.2, 19.0 and 24.2 cm respectively. The bottom of each cylinder was covered by a fine sieve (mesh 450 μm). The cylinders were filled with the wetted manure to a height of 4 cm and contained the equivalent of 20, 50, 80, 120 and 210 g per specimen. The worms were also observed over a period of 63 days. The medium was searched for cocoons every seven days and the biomasses of the worms were determined individually. In all cases the means for each density were used to plot computer assisted graphs to obtain graphs of "best fit". R^2 values represent the percentage fit of the plotted graphs. Moisture determinations were also performed as mentioned above.

Mean cocoon numbers refer to the mean number of cocoons per single worm per day unless expressed differently in terms of number of worms and period.

The worms in the containers had ample food throughout the study since one third of the substrate in each flask or cylinder was replaced with fresh medium from the same source every seven days.

RESULTS AND DISCUSSION

Influence of worm density

The results obtained from the biomass determinations of the first series of experiments are presented in *Figure* 1. Flasks with a worm density of 12, 16 and 20 worms did not at any stage differ significantly ($p>0.05$) in terms of worm growth when subjected to a chiquadrate test. Flasks with worm densities of 4 and 8 worms not only differed significantly but also from those with worm densities of 12, 16 and 20. The heaviest worms were obtained at the lower densities (*Figure* 1).

The similarity in growth obtained at the higher densities of 12, 16 and 20 worms shows a remarkable resemblance to the results obtained by Reinecke and Viljoen (1990) for *Eisenia fetida* for higher densities. The latter authors did not provide food at regular intervals to the worms but provided food initially after they had calculated the amount of food that would sustain the worms for the duration of the experiments. In the present study the possibility that food could have become a limiting factor was ruled out. One can therefore conclude that space was the limiting factor, provided that it is taken into account that the differences in worm densities between the experimental groups containing 12 and 16 and 16 and 20 worms each were not as big as that between other groups.

The regression lines of worm density against worm biomass at the various time intervals are presented in *Figure* 2. A clear relation was obtained showing that worm biomass was smaller at higher densities at all stages of the observation period. This is a clear indication that biomass was dependent on density as such.

The results obtained from the cocoon counts at the various worm densities are presented in *Figure* 3. A significant difference occurred between the flasks containing four worms and those containing eight worms. This observation is very similar to that of Reinecke and Viljoen (1990) on *Eisenia fetida*. Increased worm density seemed to affect cocoon production more adversely than it affected worms biomass. The low percentage fit of the lines in *Figure* 3 is an indication of the fluctuations that occurred in cocoon production. The cumulative cocoon production showed that the cocoon production of individuals in the group of four worms was significantly higher than those of the other groups. Worms in groups of twelve

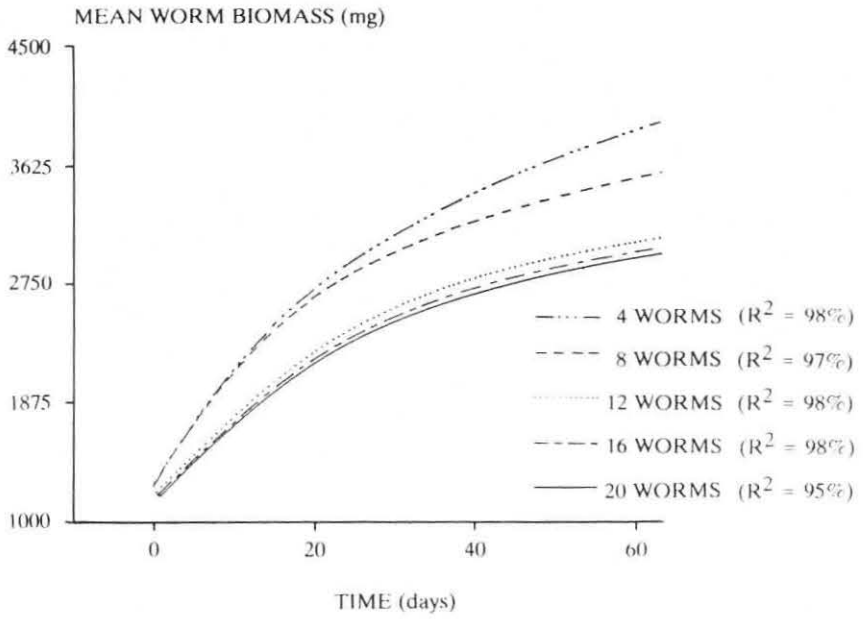

Figure 1. – Changes in the mean biomass of *Eudrilus eugeniae* kept at various densities in the same amount of organic substrate (720 g) at a moisture of 50% and a temperature of 25 °C. R^2 values indicate percentage fit of curves.

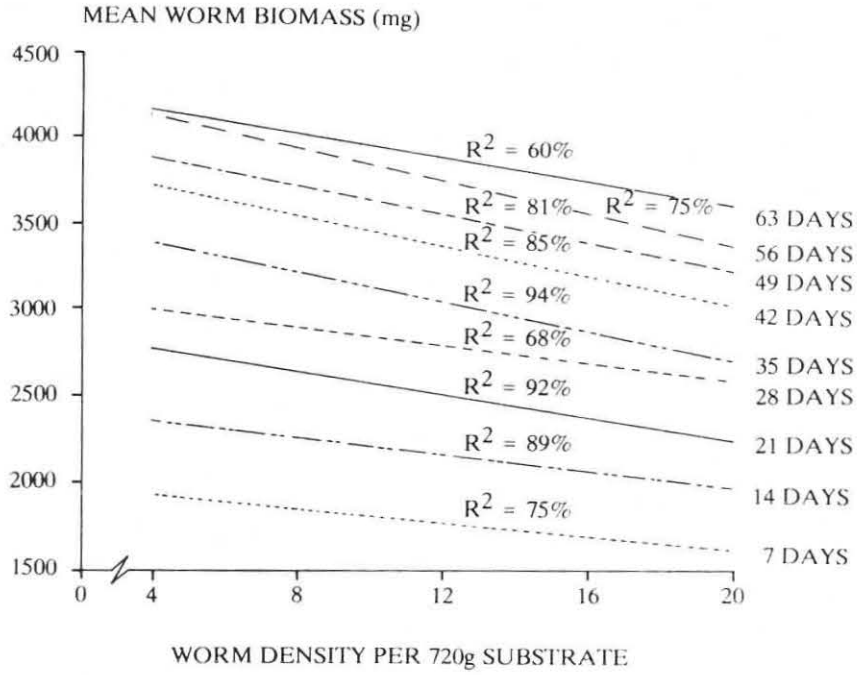

Figure 2. – Relation between mean worm density and mean biomass for *Eudrilus eugeniae* at the various stages of the observation period.

produced only about half the number of cocoons produced by worms in groups of four. A linear relation between worm density and coccon production was reliably established (*fig.* 4). The worms did not differ in biomass at densities of 12, 16 and 20 worms but nevertheless differed considerably in terms of cocoon production (*fig.* 3).

In the second series of experiments, in which various volumes arranged in cylinders of different diameters were used with a constant number of worms in each, the influence of worm density was also observed. The results of the biomass determinations are presented in *Figure* 5. No decline in worm biomass occurred similar to that observed by Reinecke and Viljoen (1990) for *Eisenia fetida*. This is a further indication that food never became a limiting factor during the observation period. This same phenomenon is also borne out by the results of the cocoon production studies (*fig.* 6), clearly showing that the bigger worms (at the lowest worm densities) also produced the most cocoons.

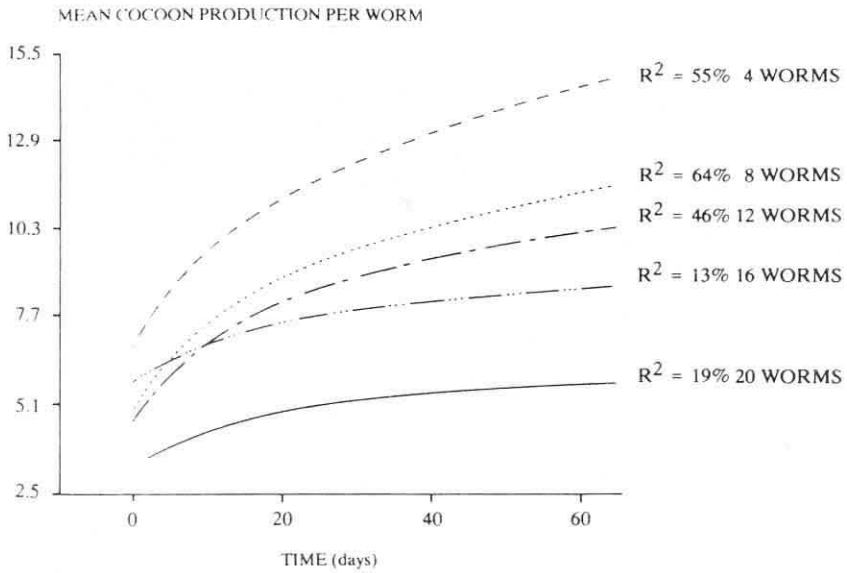

Figure 3. – Changes in mean cocoon production per worm for *Eudrilus eugeniae* kept at the various worm densities in the same amount of organic substrate (720 g) with a moisture content of 80% and at a temperature of 25 °C.

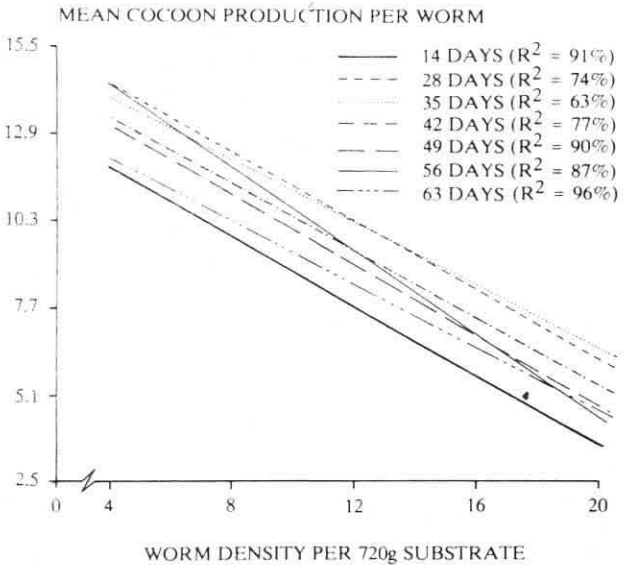

Figure 4. – The relation between mean worm density and mean cocoon production per worm for *Eudrilus eugeniae* at various stages of the observation period.

CONCLUSION

This study on *Eudrilus eugeniae* is in close agreement with the findings on the European compost worm, *Eisenia fetida* (Reinecke and Viljoen, 1990). In order to maintain continuous growth and reproduction in worm beds containing the African Nightcrawler, vermiculturists should not only pay attention to factors such as moisture, temperature and food availability. They should endeavour to maintain population densities close to the optimum for growth and reproduction. The results of the present study emphasize the necessity of preventing worm beds from becoming overcrowded. Worms will tend to be smaller and less productive under crowded conditions, and this will happen in spite of the fact that sufficient food is available. It is well known that changes in food availability will quickly affect cocoon production (Reinecke and Viljoen, 1990).

It should also be kept in mind that in worm beds the age distribution of worms will invariably contribute to the complexity of the situation since worms in different stages of development will have different effects on the system. Not all the worms that are actively feeding and utilizing space will be in the reproductive phase as was the case in the present study. Population density, in contrast to worm density as used here, may affect growth and reproduction somewhat differently.

The deposition of cocoons in the upper layers of the substrate and the fact that the worms also feed close to the surface allows for the development of harvesting methods which could remove the upper part of the worm bed and maintain worm densities within required limits.

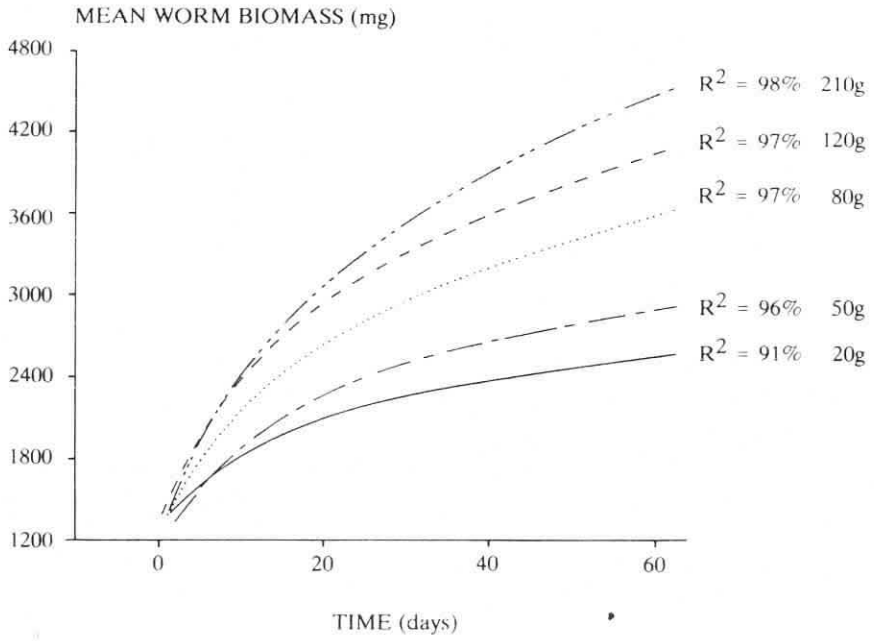

Figure 5. – Changes in mean biomass of groups of six specimens of *Eudrilus eugeniae* kept in cylinders of different diameters containing different amounts of organic substrate (dry weight). Three replicates were used in each case.

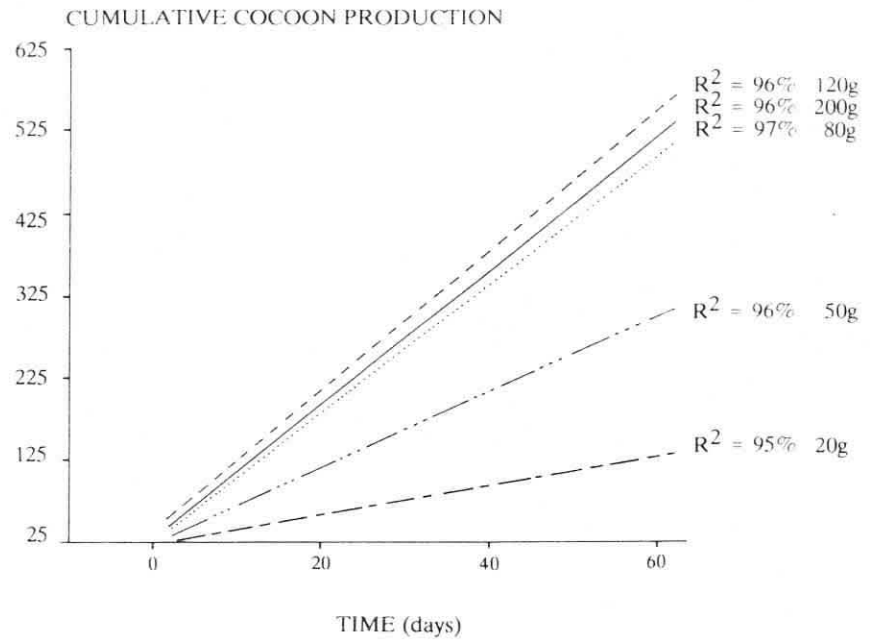

Figure 6. – The cumulative cocoon production of groups of six specimens of *Eudrilus eugeniae* kept in cylinders of different diameters containing different amounts of organic substrate (dry weight) as indicated on the graphs.

Acknowledgments

The authors are indebted to Mr. O. Kalberlah from the Technical University of Braunschweig for assistance in the performance of the research. We gratefully acknowledge the financial assistance rendered by the Federation for Research and Development and Potchefstroom University where part of this work was performed.

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